HF Training

Multi-Protocol Transceiver IC

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TEXAS INSTRUMENTS

HF Multi-Protocol Transceiver IC

RI-R6C-001A

l **Multi-Protocol Transceiver IC**

- Complies with Tag-it™ protocol
- Complies with ISO 15693-2 .
- Complies with ISO 14443-2 (Type A)
- Supports "Transparent Mode"

l **Functionality**

- Short to mid range applications
- Low additional component count
- Low power consumption
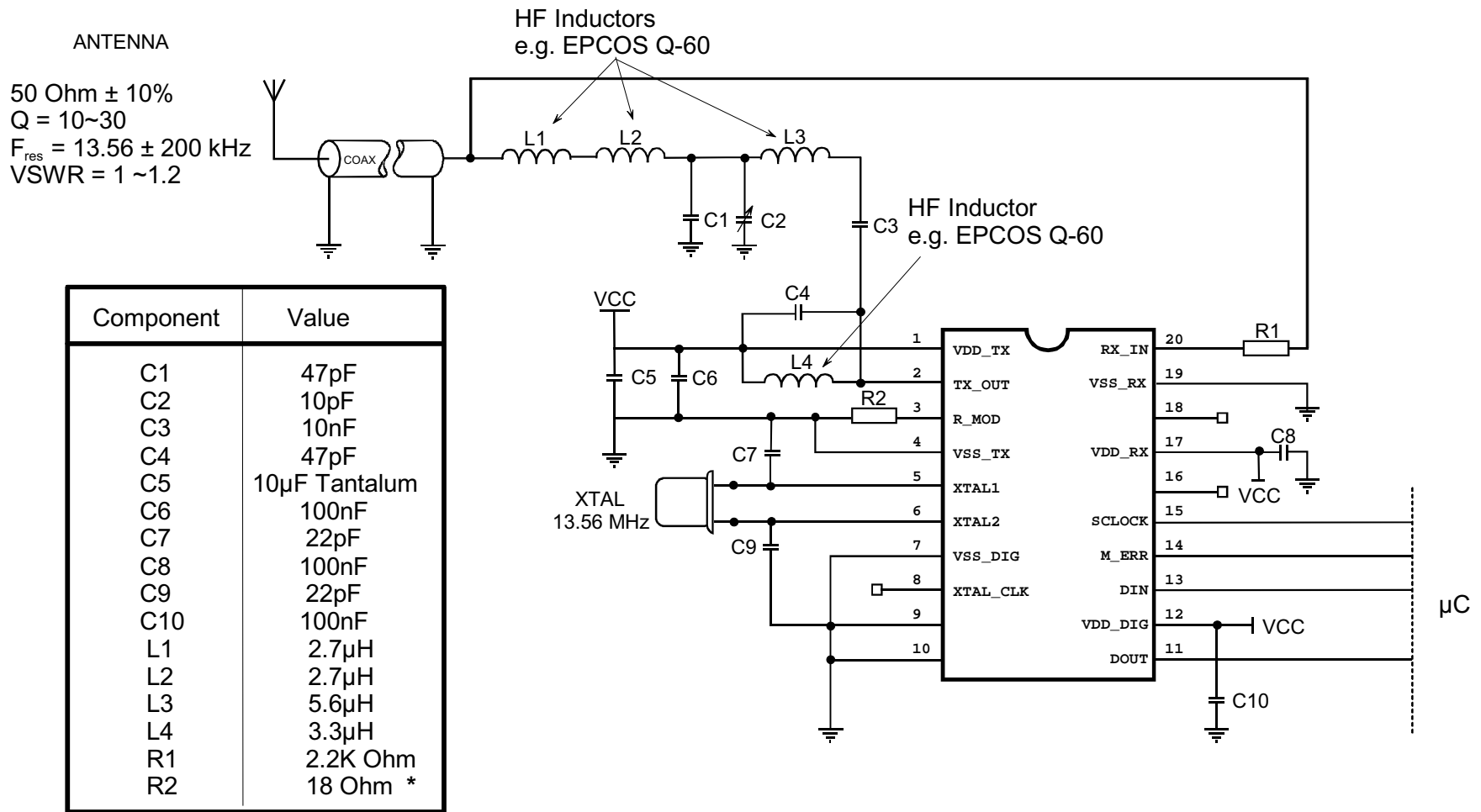- 200 mW RF power into 50 Ohms
- Serial interface

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►**Transceiver IC Pinouts**

```
 1  VDD_TX           RX_IN  20
 2  TX_OUT          VSS_RX  19
 3  R_MOD                   18
 4  VSS_TX          VDD_RX  17
 5  XTAL1                   16
 6  XTAL2           SCLOCK  15
 7  VSS_DIG          M_ERR  14
 8  XTAL_CLK           DIN  13
 9                 VDD_DIG  12
10                   DOUT   11
```

Pin	Name	Description
1	VDD_TX	Transmitter power supply
2	TX_OUT	Output transistor drain connection
3	R_MOD	External resistor to set 10% modulation depth mode
4	VSS_TX	Transmitter section ground
5	XTAL1	Pin 1 of Xtal resonator
6	XTAL2	Pin 2 of Xtal resonator& external system clock input
7	VSS_DIG	Digital section ground
8	XTAL_CLK	Buffered output of Xtal oscillator
9	not used	To be grounded for normal operation
10	not used	To be grounded for normal operation
11	DOUT	Data output for serial link
12	VDD_DIG	Digital section power supply
13	DIN	Data input for serial link
14	M_ERR	Manchester Protocol error flag
15	SCLOCK	Serial link clock
16	not used	To be left unconnected for normal operation
17	VDD_RX	Receiver section power supply
18	not used	To be left unconnected for normal operation
19	VSS_RX	Receiver section ground
20	RX_IN	Receiver input

ANTENNA

50 Ohm ± 10%
Q = 10~30
F_{res} = 13.56 ± 200 kHz
VSWR = 1 ~1.2

HF Inductors
e.g. EPCOS Q-60

HF Inductor
e.g. EPCOS Q-60

Component	Value
C1	47pF
C2	10pF
C3	10nF
C4	47pF
C5	10µF Tantalum
C6	100nF
C7	22pF
C8	100nF
C9	22pF
C10	100nF
L1	2.7µH
L2	2.7µH
L3	5.6µH
L4	3.3µH
R1	2.2K Ohm
R2	18 Ohm *

* 18 Ohm = 20% Modulation (Recommended)
   12 Ohm = 10% Modulation

Improved Matching Circuit

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l **Matching circuit calculation:**

– Schematic of a double L matching circuit = <u>T matching network</u>

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Calculation:

$$Rs = 5\Omega \qquad Q = 40 \qquad Rl = 50\Omega \qquad f = 13,56 Mhz$$

$$R = Rs \cdot (Q^2 + 1) \qquad \text{R = Virtual resistance (instead of Xp1//Xp2)}$$

$$Xs1 = Q \cdot Rs$$

$$L1 = \frac{Xs1}{2 \cdot \pi \cdot f} \qquad \boxed{L1 = 2,3\mu H}$$

$$Xs2 = Q2 \cdot Rl$$

$$L2 = \frac{Xs2}{2 \cdot \pi \cdot f} \qquad \boxed{L2 = 7,4\mu H}$$

$$Xp1 = \frac{R}{Q} \qquad Q2 = \sqrt{\frac{R}{Rl} - 1} \qquad Xp2 = \frac{R}{Q2} \qquad Xp = \frac{Xp2 \cdot Xp1}{Xp2 + Xp1}$$

$$C = \frac{1}{2 \cdot \pi \cdot f \cdot Xp} \qquad \boxed{C = 77pF}$$

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Caution:

- Check the resonant frequency of the inductor!

- Use only low tolerance components for the matching network to achieve optimum SWR!

For Example:

    L1 and L2: +/-10% tolerance

    C2:   +/-2% tolerance, temp. coefficient +-30ppm COG (Murata),
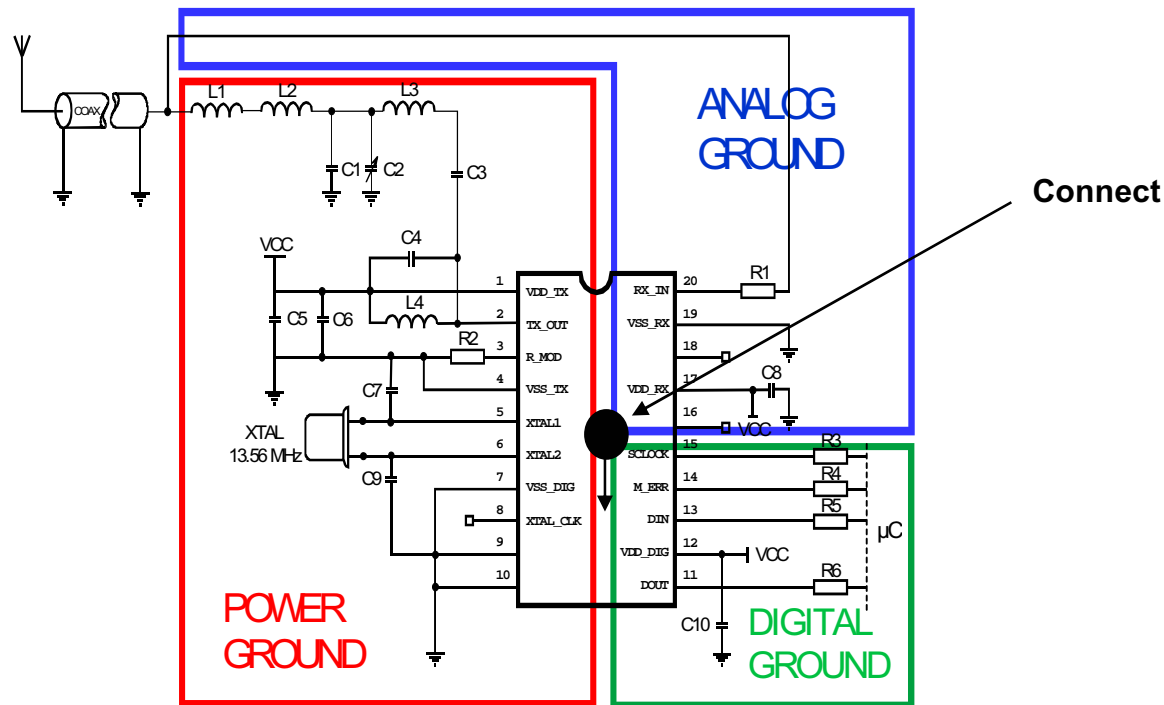
Bad choice: Z5U material +22/-85% tolerance!!!

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l **Suggested improvements to the application circuit:**

– Add a resistor between L4/C4 and TX_OUT/C3

– This action improves the EMC due to the decrease of the slew rate of the output MOS-FET.

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– Further decoupling of VCC and Interface lines with series resistance
  ■ Very cheap improvement regarding noise behavior
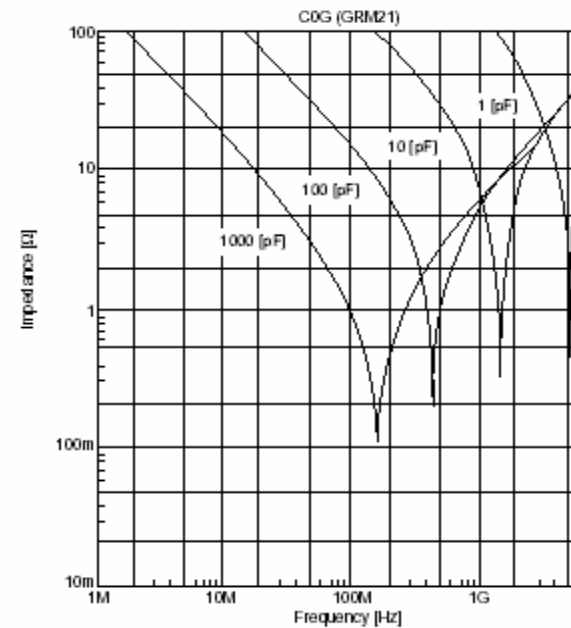– Split the receive and transmit ground-planes

  ■ Better de-coupling of receiver
– Avoid using RS232 drivers that use switching frequencies in the range of 424 to 484 kHz or their harmonics (e.g. 141 kHz x 3 = 424 kHz)

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– Add 1 nF ceramic capacitors in parallel to the C6, C8 and C10, 100 nF blocking capacitors at the IC VDD pins

- These capacitors should be placed closest to the supply pins!

- Ceramic capacitors have a much better HF noise filtering behavior due to their low inductance.
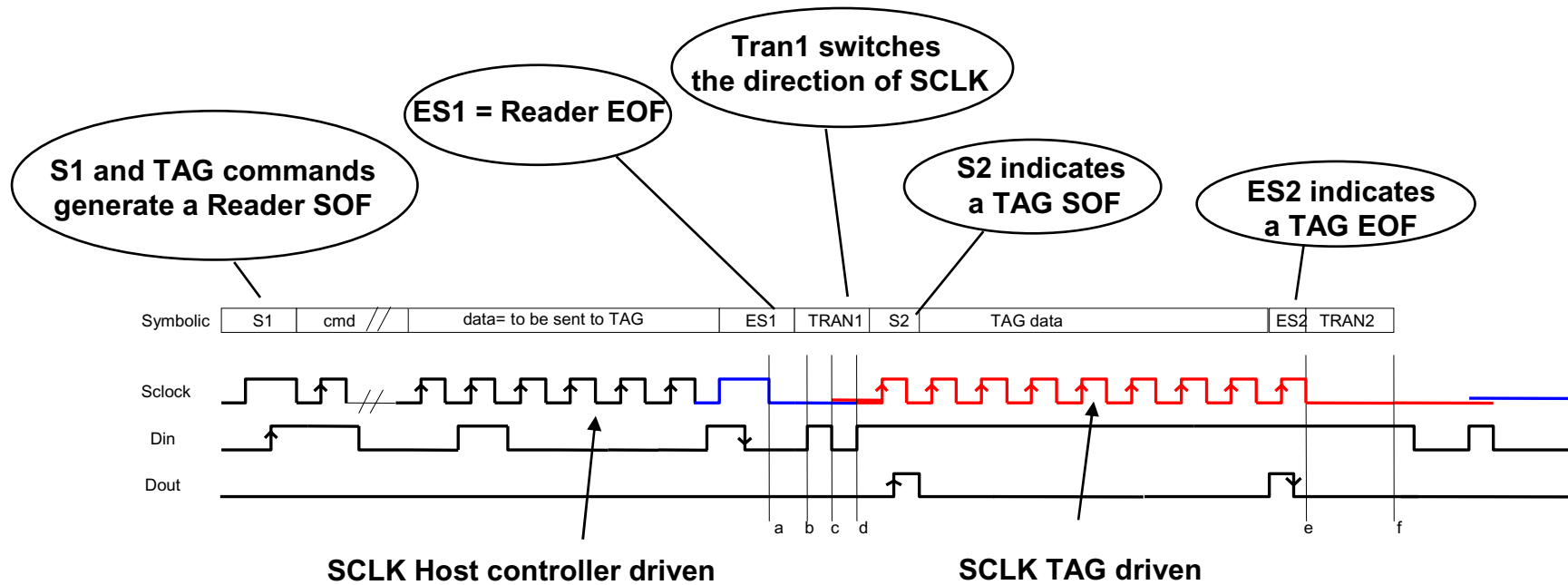
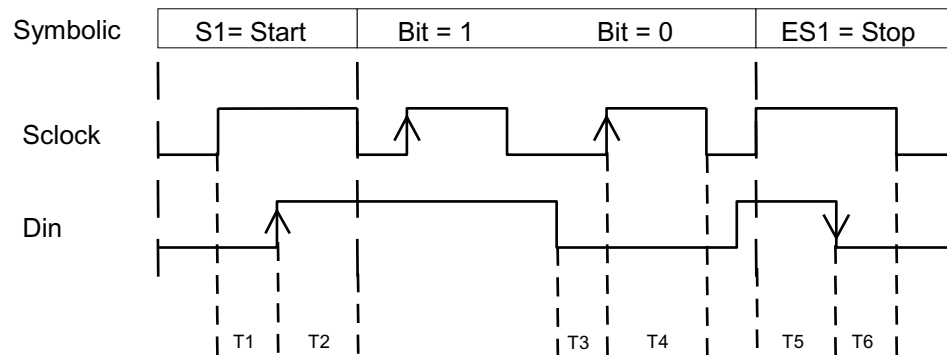■ Impedance-Frequency Characteristics

Example (C10)

μC

SCLOCK 15
M_ERR 14
DIN 13
VDD_DIG 12 — VCC
DOUT 11

1nF 100nF

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Basic communication structure:

Basic Request / Response

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l **First steps after assembly of a prototype board:**

1. Check soldering and schematic
2. Switch on power supply and check supply voltages
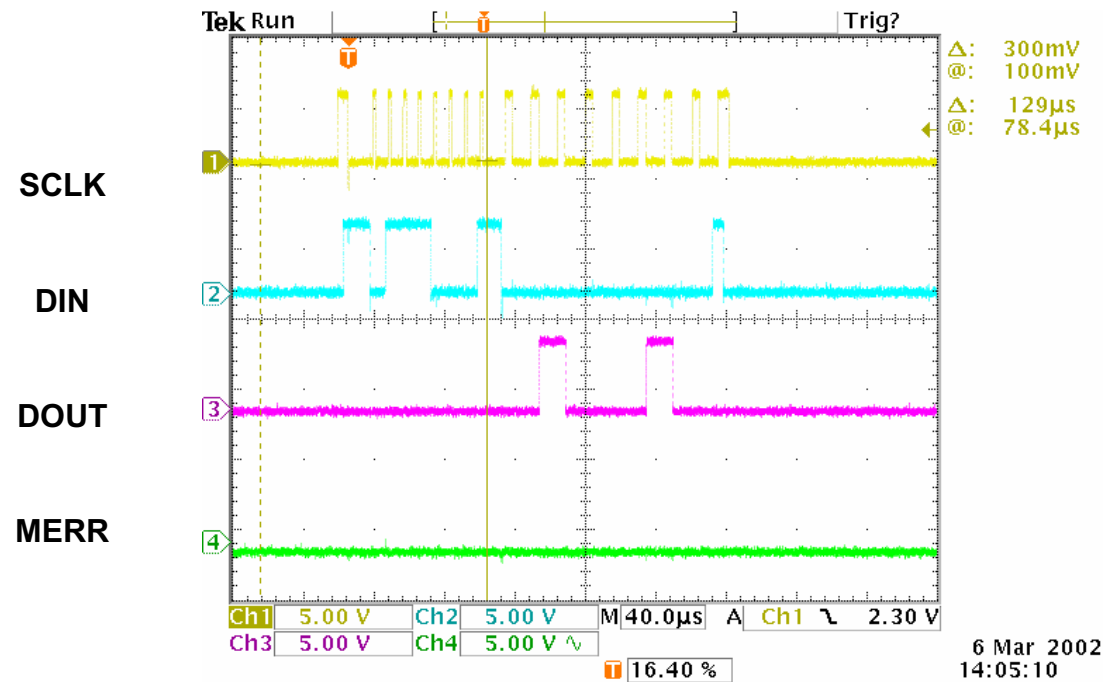3. Check timing!

Definitions

Symbolic	S1= Start	Bit = 1	Bit = 0	ES1 = Stop

Sclock

Din

T1   T2   T3   T4   T5   T6

Minimum timings

T1: 300ns   T4: 600ns
T2: 300ns   T5: 300ns
T3: 66ns   T6: 300ns

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4. Read configuration register $0x71_{hex}$ (MSB first)

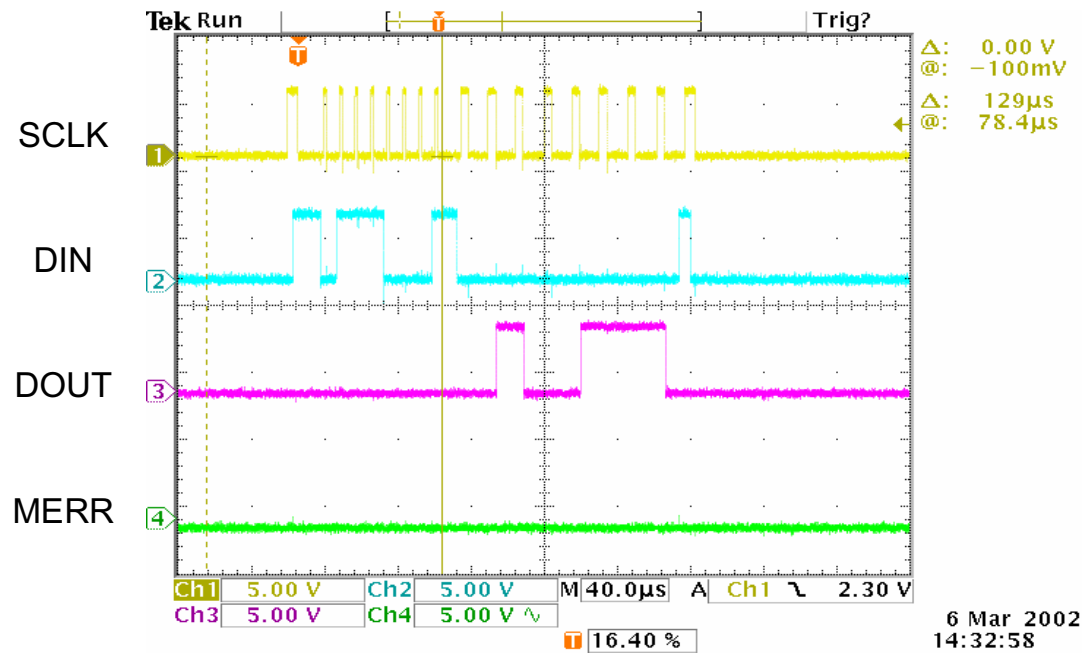**Result =** 0x22 **(MSB first)**

SCLK

DIN

DOUT

MERR

5. Write to configuration register 0x7D$_{hex}$ (MSB first)

Content = **0x27** (MSB first)   ISO 15693 / down link 1 out of 4, 100% modulation, one subcarrier (ASK) high data-rate (~26 kb), Manchester decoder disabled
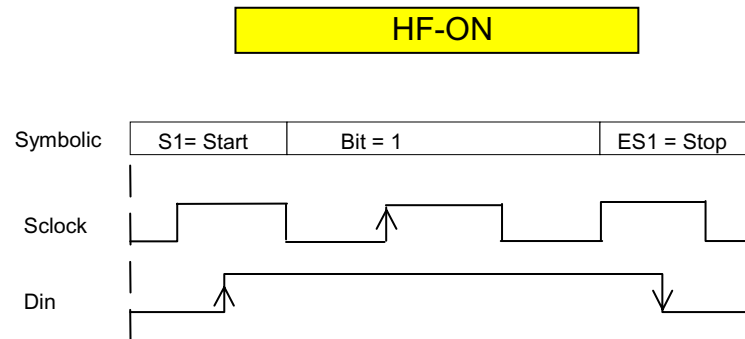
6. Read configuration register 0x71$_{hex}$ (MSB first)

Result = **0x27** (MSB first)

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7. Switch on HF:

This operation must be performed first, otherwise SOF of the reader is not modulated properly.

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8. Send a read TAG command (e.g. get Inventory)

ISO Command Set:

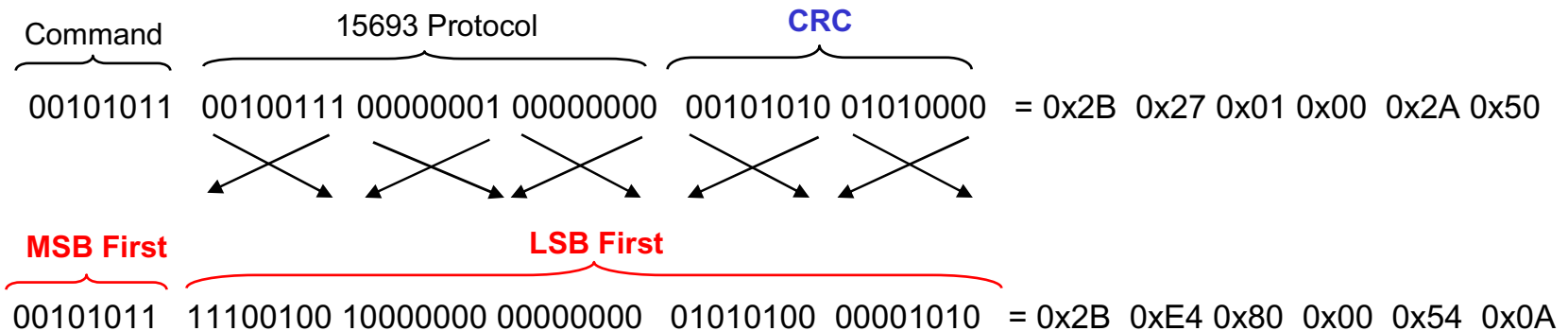| Command Code		Function	Request Mode						
Hex	Binary (LSB)		Inventory	Addr.	Non Addr.	Select	AFI	Opt. Flag	
ISO15693 Mandatory Commands									I S O
0x00	0000 0000	RFU	-	-	-	-	-	-	
0x01	0000 0001	**Inventory**	√	-	-	-	√	0	D E F I N E D
0x02	0000 0010	**Stay Quiet**	-	√	-	-	-	0	
0x03-0x1F	0000 0100	RFU	-	-	-	-	-	-	
ISO15693 Optional Commands									
0x20	0010 0000	**Read_Single_Block**	√	√	√	√	√	0/1	
0x21	0010 0001	**Write_Single_Block**	-	√	√	√	-	-/1	
0x22	0010 0010	**Lock_Block**	-	√	√	√	-	-/1	
0x23	0010 0011	**Read_Multi_Blocks**	√	√	√	√	√	0/1	C O M M A N D S
0x24	0010 0100	Write_Multi_Blocks	-	-	-	-	-	-	
0x25	0010 0101	**Select_Tag**	-	√	-	-	-	0	
0x26	0010 0110	**Reset to Ready**	-	√	√	√	-	0	
0x27	0010 0111	**Write_AFI**	-	√	√	√	-	-/1	
0x28	0010 1000	**Lock_AFI**	-	√	√	√	-	-/1	
0x29	0010 1001	**Write_DSFID**	-	√	√	√	-	-/1	
0x2A	0010 1010	**Lock_DSFID**	-	√	√	√	-	-/1	
0x2B	0010 1011	**Get_System_info**	√	√	√	√	√	0	
0x2C	0010 1100	**Get_M_Blk_Sec_St**	√	√	√	√	√	0	
0x2D-0x9F	0010 1101	*RFU*	-	-	-	-	-	-	
TI Custom Commands									T I
0xA0	1010 0000	RFU	-	-	-	-	-	-	
0xA1	1010 0001	RFU	-	-	-	-	-	-	
0xA2	1010 0010	**Write_2_Blocks**	-	√	√	√	-	-/1	C M D s
0xA3	1010 0011	**Lock_2_Blocks**	-	√	√	√	-	-/1	
0xA4-0xDF		RFU	-	-	-	-	-	-	
TI Proprietary Commands									
0xE0-0xFF		RFU	-	-	-	-	-	-	

l **Inventory Command Sequence:**

0x2B (Command, Transceiver)   ISO 15693, 1 out of 4, 100% modulation, FM, high Data-rate

Calculate CRC on these bytes

0x27, (Request flags):   FM, **high data-rate, use table 5 of ISO-spec, no protocol** format extension, AFI not present, **1 slot, Option flag = 0, RFU = 0**   (see ISO 15693-3 for details)

0x01, (Command, Tag):   Inventory Command
0x00, Mask length: 0
0x2A, 0x50 :   CCITT-CRC (Reverse, Start value 0xFFFF, 1's compliment)

Command string :

Command   15693 Protocol   CRC

00101011   00100111 00000001 00000000   00101010 01010000   = 0x2B 0x27 0x01 0x00 0x2A 0x50

MSB First   **LSB First**

00101011   11100100 10000000 00000000   01010100 00001010   = 0x2B 0xE4 0x80 0x00 0x54 0x0A

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l CRC calculation:

For the ISO 15693 tag protocols use:

– CCITT-CRC, Byte entry, Reverse direction, Start value 0xFFFF, 1's Complement

For the Tag-it™ HF tag protocol use:

– CCITT-CRC, Bit entry, Forward direction, Start value 0xFFFF, 1's compliment
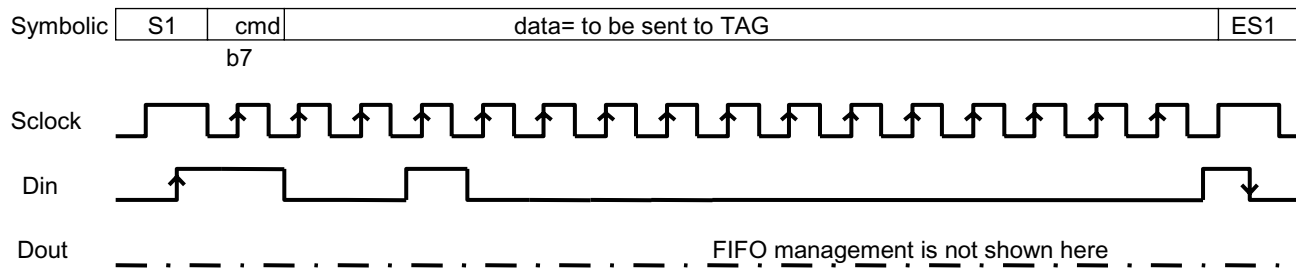
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Inventory command   TAG answer

MERR pulse indicates that modulation on HF is finished

Two zeroes are added to the TAG answer in front of EOF!

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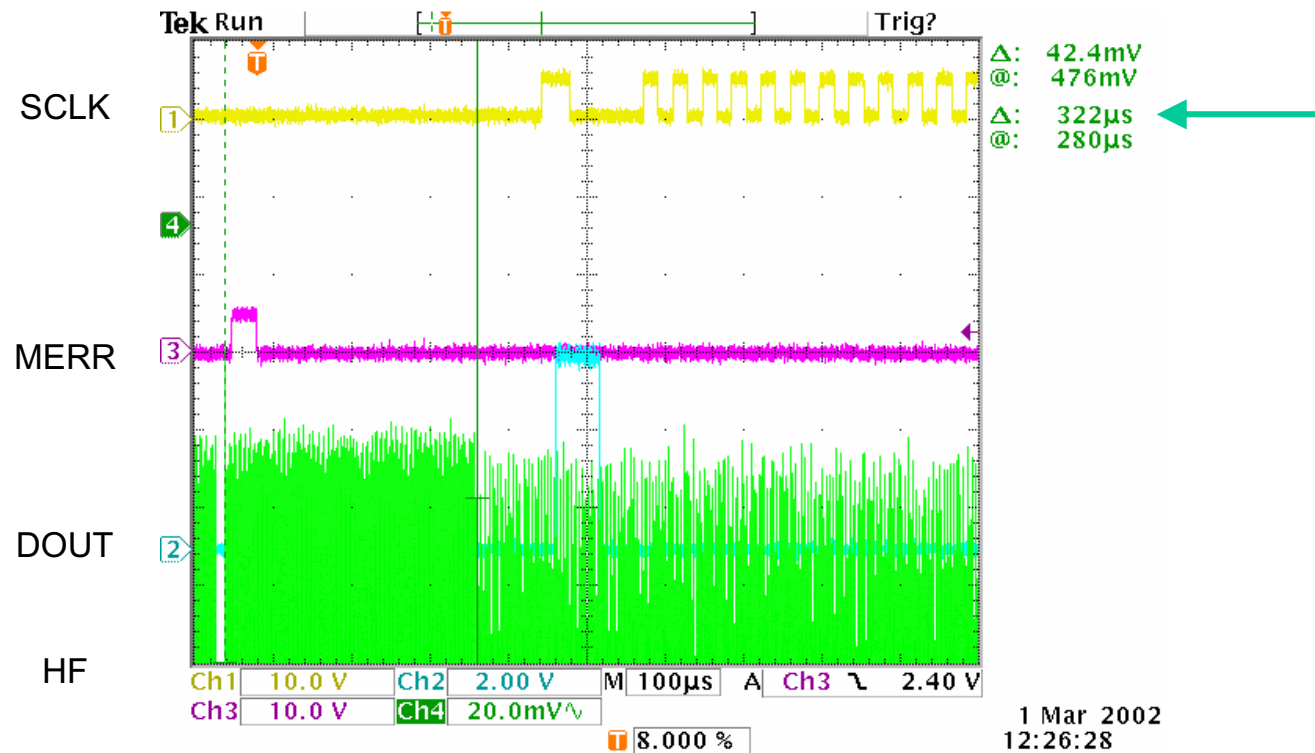
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l **Register mode:**

Once the transceiver is initialized by the command byte in front of the data to be sent to the TAG, or by initializing the configuration register, the command byte does not need to be sent again, until the configuration needs changing again.

Symbolic	S1	cmd	data= to be sent to TAG	ES1
		b7		

Sclock

Din

Dout — FIFO management is not shown here

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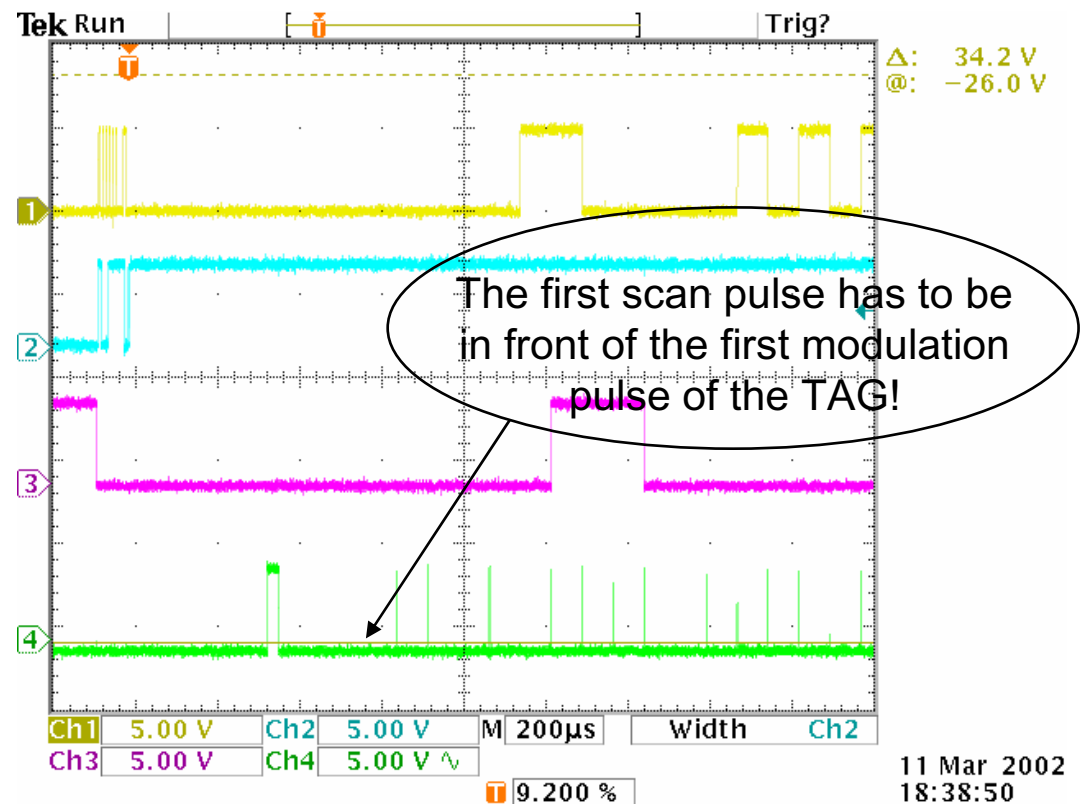l **Set timing initialization:**

318,64 – 323,34 µs after the rising edge of EOF of the reader, the TAG should send its answer (ISO 15693-3).
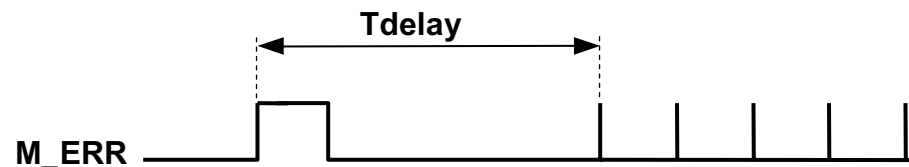
1 Checking the Delay

- Due to differences in the circuitry, it is possible, that there might be an additional delay in the answer.

- If this occurs, the Manchester decoder of the Transceiver IC will not work properly anymore.

- You can visualize the scan pulses of the Manchester decoder with following command sequence:

0x7B Data: 1100 0101 0110 0
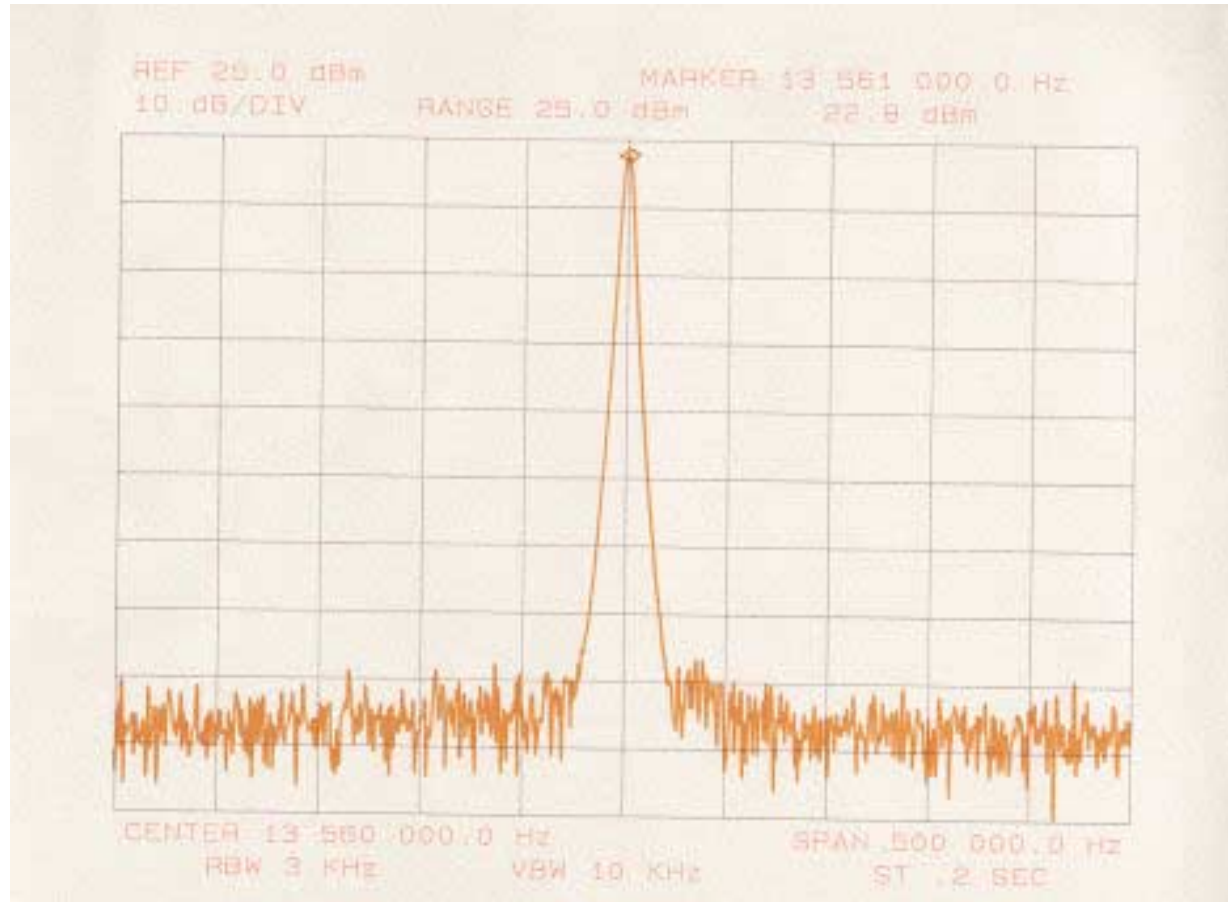
(Boundary scan ON, Tdelay = 319 μs)

The first scan pulse has to be in front of the first modulation pulse of the TAG!

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❶ **Solution** - Change the Delay

	Tdelay [µs]	Timing offset [7 bits]
Minimum Value	306 µs	0000000
Typical	319 µs	0101100
Maximum Value	343 µs	1111111

Tdelay

M_ERR
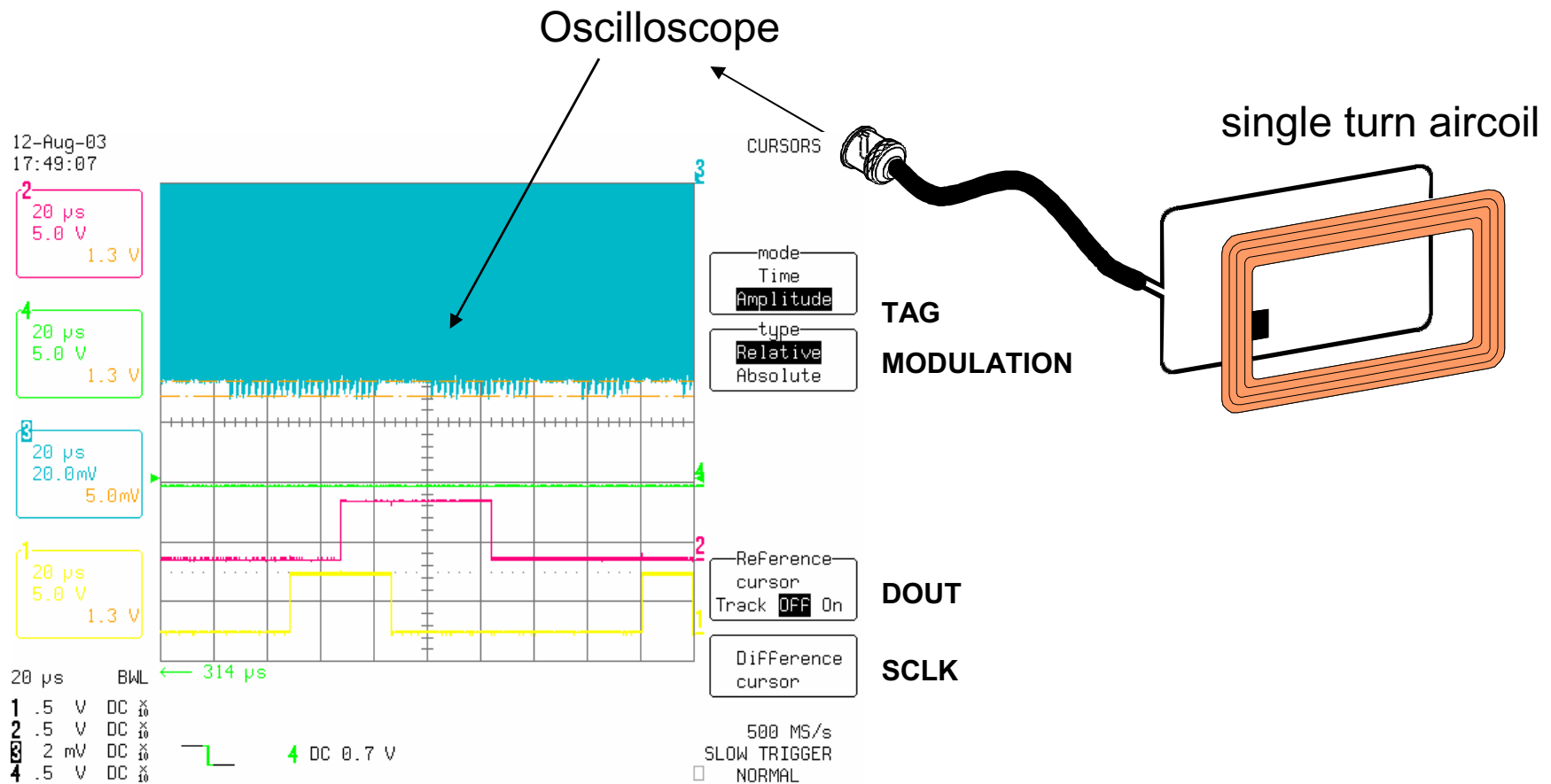
Example: 7 bits = 0101100 = $2C_{hex}$ = 44_{dec}

1 Bit equals 295 ns   44 x 295 = 12980nS = 13 µs

Tdelay = 306 + 13 = 319 µs

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1 Output power measurement:

22.8dBm = ~200mW

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1 **Transponder modulation measurement:**

Oscilloscope

single turn aircoil
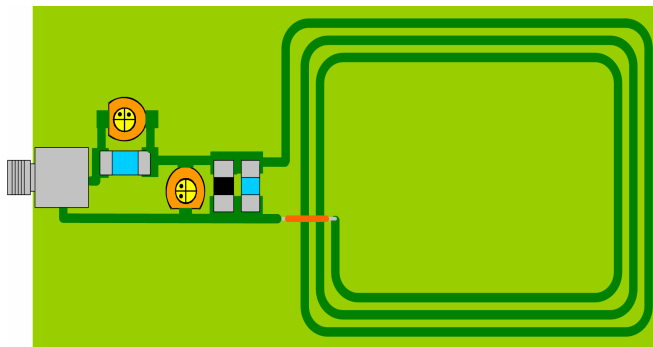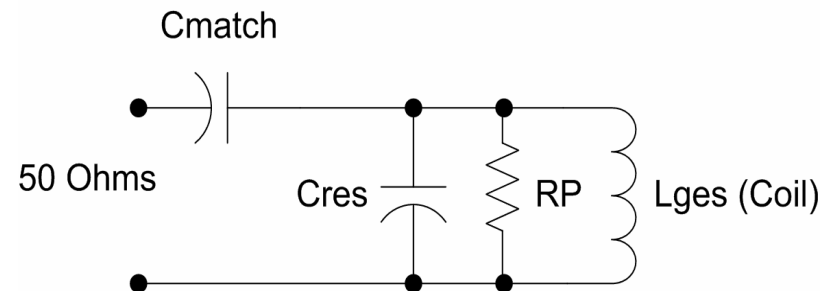

TAG

MODULATION

DOUT

SCLK

l Antenna design:

1. Define and create Antenna Loop

PCB or wire wound

Equivalent circuit

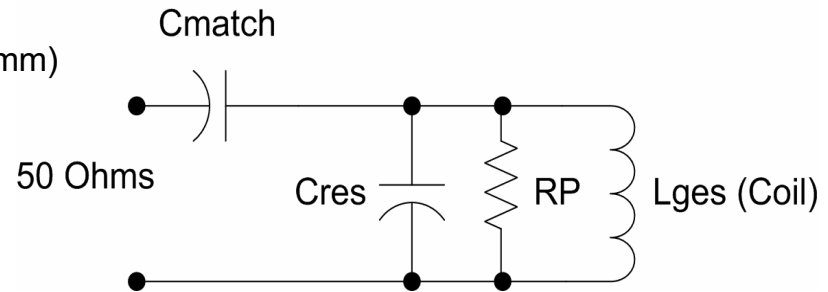2. Measure the inductance of the Loop

3. Calculate the components

L_{ges} = 1.27 µH (given 3 turn PCB, 30 × 40 mm)

Q = 20

Rs = 50 Ohms

f = 13.56 × 10^6 Hz

$\omega = 2\pi f$

$RP = (Q^2 + 1) \times Rs$ $Rp = 2.005 \times 10^4$ Ohms

$Xs = Q \times Rs$ $Xs = 1000$

$C_{match} = \dfrac{1}{\omega Xs}$ $C_{match} = 1.174 \times 10^{-11}$ F

$Xp = \dfrac{Rp}{Q}$ $Xp = 1.0025 \times 10^3$

$L1 = \dfrac{Xp}{\omega}$ $L1 = 1.177 \times 10^{-5}$ H   intermediate inductor, for calculation only!

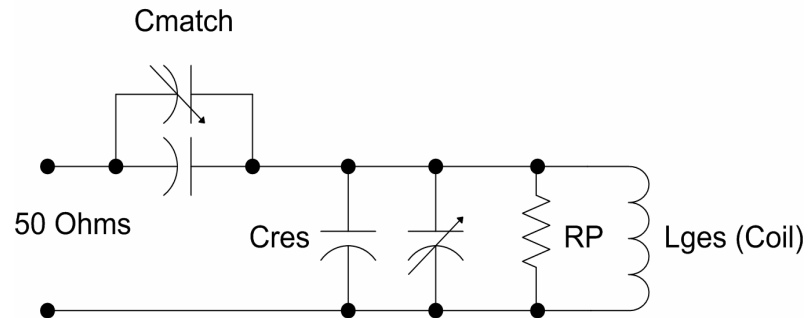$L2 = \dfrac{L_{ges} \times L1}{L1 - L_{ges}}$ $L2 = 1.424 \times 10^{-6}$ H   intermediate inductor, for calculation only!
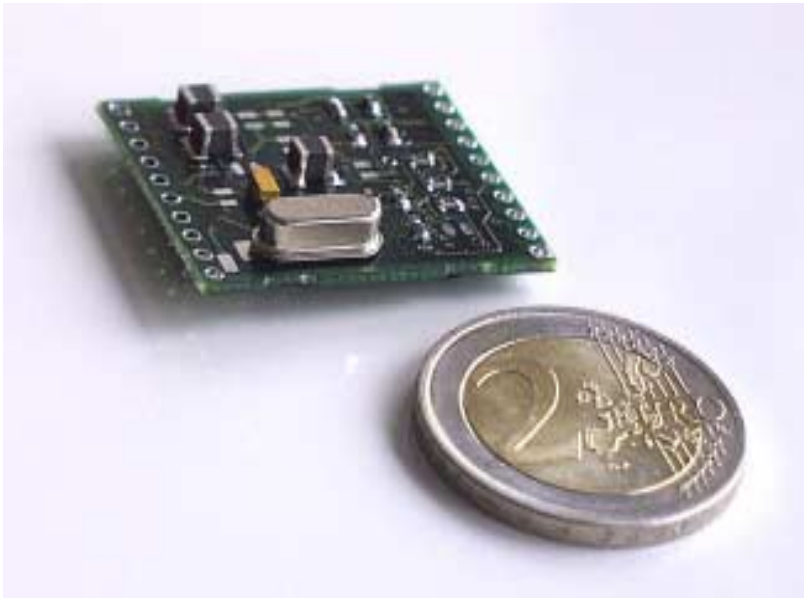
$C_{res} = \dfrac{1}{\omega^2 \times L2}$ $C_{res} = 9.676 \times 10^{-11}$ F

Cmatch

50 Ohms

Cres   RP   Lges (Coil)

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4. Add variable (fixed) capacitors for fine tuning:

• low tolerance components should be used – COG or NPO type capacitors

• when optimum capacitor values have been found, the variable capacitors can be removed,

• plan the space for 2 fixed, fine tuning capacitors at C_{res} and C_{match}

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Very small and cheap products are available already!

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l Resources

- Reference Guide (11-07-21-001) http://www.ti-rfid.com

- ISO/IEC 15693 Part 2/3   http://www.iso.ch

- ISO/IEC 14443 Part 2/3/4   http://www.iso.ch

- Antenna design notes
    http://www.ti.com/tiris/docs/manuals/appNotes/HfAntennaDesignNotes.pdf

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